UNIVERSITY OF SURREY©

Faculty of Engineering and Physical Sciences
Department of Electronic Engineering

Undergraduate Programmes in Electronic Engineering

Module EEEM010; 15 Credits

Image Processing and Vision

FHEQ LEVEL 7 Examination

Time allowed: Two hours

Semester LSA
2015/16

READ THESE INSTRUCTIONS

Answer only THREE questions

If you answer more than THREE questions, the highest scoring THREE questions will count towards this assessment.

On the front sheet of each book, complete a list of questions attempted in that book in the order they appear. Then draw a line below this list and add the question numbers you have attempted in the other books.

Where appropriate the mark carried by an individual part of a question is indicated in square brackets [ ].

Additional materials

Candidates may use only calculators which are non-programmable and with no alphanumeric memory.

Casio Models FX115MS, FX115W or FX115S, or other models with lower functionality.
EE Formula Booklet.

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1.

(a) State an example of an additive and a subtractive primary model for colour mixing, and describe a real-world application of each.

[20%]

(b) Sketch a diagram of the CIE XYZ colour space, and use it to explain why additive or subtractive models of colour with physically realisable primaries cannot be used to represent all physically realisable colours.

[20%]

(c) Dark green is represented by (0.1, 0.5, 0.3) in RGB space.

(i) Convert this colour from RGB to the CMYK colour space. Show all your working.

[15%]

(ii) Convert this colour from RGB to the HSV colour space. Show all your working.

[15%]

(d) A greyscale image contains pixels with the following intensities:

Pixel at location (7,4) = 120

Pixel at location (7,5) = 130

Pixel at location (8,4) = 160

Pixel at location (8,5) = 170

Calculate the intensity at location (7.7, 4.1) using bi-linear interpolation. Show all your working. You may find it helpful to construct a diagram.

[30%]

2.

(a) What is meant by the probability density function (pdf) of an image, and what does it tell us about an image?

[5%]

(b) Briefly describe the effect on an images pdf of the following operations:

(i) Binary thresholding

[5%]

(ii) Brightness adjustment

[5%]

(iii) Contrast adjustment

[5%]

(c) Describe the process of histogram equalisation and how it may be used to enhance image detail.

[20%]

(d) Construct a linear system that could be solved to obtain an affine transformation between a set of 3 pairs of corresponding points P and P' between two images, where $P = \begin{bmatrix} 17 & 43 & 65 \\ 45 & 77 & 48 \end{bmatrix}$ and $P' = \begin{bmatrix} 59 & 59 & 89 \\ 28 & 73 & 86 \end{bmatrix}$. You do not need to solve the linear system.

[30%]

(e) Describe the process by which multiple images of a scene may be combined to produce an image with higher resolution (super-resolution).

[30%]

3.

(a) Two types of noise commonly encountered in images are salt and pepper noise, and additive Gaussian noise.

   (i) How are these types of noise manifested in images? Name a common source of each type of noise.

   [20%]

   (ii) Recommend a procedure for digitally reducing each type of noise in an image. Ensure you provide a full description of the procedure in each case.

   [30%]

(b) Making reference to the frequency domain, explain why the Gaussian filter is more suitable than the Box (Mean) filter for blurring an image via convolution.

[10%]

(c) Making reference to the frequency domain, explain why the Laplacian of Gaussian is suitable for sharpening images via convolution.

[10%]

(d) The Laplacian of Gaussian can also be used for removing small visual defects in an image. Explain with full mathematical detail how this can be achieved.

[30%]

4.

(a) Describe a gradient domain operator commonly used to compute descriptors from an image for the purpose of object recognition.

[15%]

(b) Explain how a convolutional neural network (CNN) can be adapted to learn an optimal descriptor for a set of training images, within the context of object recognition.

[15%]

(c) Compare and contrast the approaches of Vector Quantization (bag of words) and VLAD for encoding representations of image descriptors for object recognition.

[20%]

(d) What is meant by the α-channel in the context of the Porter-Duff model for image compositing?

[10%]

(e) Outline the basic framework for compositing as specified by Porter and Duff. You do not need to list all 12 compositing modes.

[20%]

(f) Construct a linear system for compositing two images in the gradient domain. Explain how the system may be applied to seamlessly composit images.

[20%]

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